Exemption No. 10069

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON 98057-3356

In the matter of the petition of **The Boeing Company** for an exemption from §§ 25.779(b)(1), 25.1301(d)[1], and 25.1309(a) of Title 14, Code of Federal Regulations	**Regulatory Docket No. FAA-2009-1218**

1 - The § 25.1301(d) rule in the affected airplane's basis of certification was subsequently re-codified as § 25.1301(a)(4), at Amendment 123, but otherwise remains unchanged.

GRANT OF EXEMPTION

By letters dated December 16, 2009, and February 09, 2010, Jordan B Zundell, Lead Project Administrator, Production and Retrofit Projects, The Boeing Company, P.O. Box 3707, M/C 67-LR, Seattle, Washington 98124-2207, petitioned for a partial exemption from §§ 25.779(b)(1), 25.1301(d) and 25.1309(a) of Title 14, Code of Federal Regulations (14 CFR) as they relate to: "a possible non-operationally significant minor engine pressure ratio (EPR) limit cycle oscillation during certain ground operation, at aircraft speeds below 35 knots IAS;" for the Boeing Models 767 and Boeing Model 747 installations of Rolls-Royce RB211-524G/H Full Authority Fuel Control (FAFC) "Issue 17" software.

Rolls-Royce has determined that it is necessary to introduce the subject Issue 17 software to avoid fan flutter induced fan failures which could hazard the airplane. During testing it was discovered that the Issue 17 software also inadvertently introduces a small potential for an undesirable "limit cycle EPR oscillation (LCO) during certain low speed ground operations." While not deemed unsafe, this LCO characteristic renders the Issue 17 software noncompliant with the applicable regulations noted in the petitioners request for exemption. The proposed exemption, if granted, would permit type certification and retrofit of non-compliant FAFC Issue 17 software on the Rolls-Royce RB211-524 G/H engines of 123 existing Boeing Model 747-400/400F and 31 existing Boeing Model 767-300 airplanes. No new production airplanes are covered by this exemption.

The petitioner requests relief from the following regulation(s):

Section 25.779(b)(1), Powerplant control, which requires:

Controls	*Motion and effect*
Power or thrust----------	Forward to increase forward thrust and rearward to increase rearward thrust.

Section 25.1301(d), Function and installation, which requires:

"Each item of installed equipment must—
"Function properly when installed."

Section 25.1309(a), Equipment, systems and installations, which requires:

"The equipment, systems, and installations whose functioning is required by this subchapter, must be designed to ensure that they perform their intended functions under any foreseeable operating condition."

The petitioner supports its request with the following information:

This section summarizes the petitioner's request. The complete petition(s) is available at the Department of Transportation's Federal Docket Management System, on the Internet at http://regulations.gov, in Docket No. FAA-2009-1218.

The Rolls-Royce Model RB211-524 G/H engines installed on Boeing Model 747 and 767 airplanes are susceptible to fan flutter when fan speed is relatively high (above about 70% N1) and airspeed is below about 30 knots. Fan flutter can cause fan blade failures that hazard the airplane. Rolls Royce has developed FAFC Issue 17 software with a "Keep Out Zone (KOZ)" logic intended to prevent steady state engine operation at conditions known to cause fan flutter. During testing it was discovered that this logic has an unintended characteristic. If the throttle is moved rapidly to an EPR set point near the middle of the KOZ, an engine power oscillation can develop about the set point. This "Limit Cycle Oscillation (LCO)" renders the design noncompliant with §§25.779(b)(1), 25.1301(d) and 25.1309(a).

Evaluations by both Rolls-Royce and Boeing indicate that it's unlikely an LCO will occur during normal operation. If it does, while perceptible (i.e., a magnitude of ~ 0.05 EPR peak-to-peak and a period of ~3 seconds), it poses no identifiable safety hazard. Hence, Boeing is requesting this exemption be granted to expedite the fan flutter mitigation provided by the KOZ logic.

Public Interest

The Boeing petition provides the following to show why the exemption is in the public interest:

- *"This petition is submitted in accordance with the public interest, to expedite timely implementation of a necessary safety improvement to the engine, which otherwise would not be possible. It is done with the concurrence of both the engine manufacturer, as well as existing and prospective airline operators, in the interest of safety."*

- *"Rolls-Royce has determined that it is necessary to introduce a new standard of Full Authority Fuel Control (FAFC) software for the RB211-524G/H/-T engine to assure continued safe operation of the engines."*

- *"Rolls-Royce has analyzed the EPR oscillation behavior (LCO) and determined that, while undesirable, it does prevent stabilized running in the 'Keep Out Zone' and prevents fan flutter from occurring."*

- *"This exemption is requested to support the Rolls/Royce/European Aviation Safety Agency (EASA) timetable for addressing the safety aspect of the fan flutter issue."*

- *"Full fleet incorporation of an automated KOZ would be delayed until 2018, at the earliest, if Issue 17 software is not certified and released. This would not meet the reaction time required by the Rolls-Royce risk assessment and EASA requirements and could lead to the grounding of affected airplanes"*

- *"This characteristic can be described as a minor limit cycle EPR oscillation (LCO) occurring in a thrust range above breakaway/taxi power settings, but below any routine takeoff thrust value. It only can occur at low taxi speeds, and at power settings that are not operationally significant. Even if in rare instances the LCO occurs, it can only be marginally perceived by the flight crew, and even if detected, has no operational consequence."*

- *"Boeing has been unable to identify a scenario where the LCO oscillation could result in an unsafe condition. The worst case scenario that has been identified is a low speed Rejected Takeoff (RTO) at an initiation speed below 35 knots."*

  "Boeing and Rolls-Royce assessed the likelihood of an RTO caused by flight crews inadvertently setting EPR within the Keep Out Zone. The assessment included a review of takeoff data from over 550,000 flights from 2000 to 2009. The review did not find any takeoffs where EPR was set within the zones necessary to set up the oscillatory behavior. Based on that finding, Boeing and Rolls-Royce have concluded that exposure to the EPR oscillation during takeoff is extremely unlikely."

- *"During the 747-400 flight testing of the Issue 17 software, a series of ground handling conditions and taxi conditions were performed, which included simulation of limit conditions well beyond those expected operationally. Considerations and tests included simulation of thrust levels used for light and heavy weight taxi, up and downhill slope; turns and pivot turns, reduced number of engine taxi, strong wind effects on taxi, surface contamination, and other factors."*

  "Several conditions were demonstrated using thrust asymmetry and thrust differences significantly greater than any that might operationally result from the worst combination of KOZ and EPR oscillation on each engine (e.g., with both left engines at the minimum threshold and both right engines at the maximum threshold). Based on these assessments, the Boeing AR pilot, with concurring advice from the operator's fleet Technical pilot, concluded that there are no adverse ground handling taxi concerns or issues associated with the implementation of the KOZ, even in the event of inadvertent initiation of the observed EPR oscillation on one or more engines, including on all engines."

- *"For the 767, it is not possible to obtain a valid takeoff thrust de-rate setting sufficiently low to get into the KOZ."*

- *"The 747-400/400F Airplane Flight Manual (AFM) is being revised to limit maximum permissible takeoff de-rates to power settings above the upper limit of the KOZ."*

- *"The KOZ logic is enabled during initialization of the Full Authority Fuel Control (FAFC) during engine start. To prevent any possible or potential effects of the KOZ in-flight, the KOZ logic is disabled when airspeed exceeds 35 knots and remains disabled until the engine is shutdown."*

- *"Since the KOZ is disabled at 35 knots, and is not re-enabled prior to engine shutdown, the KOZ and EPR oscillation behavior might rarely occur during taxi-out but not during taxi-in to a gate or ramp."*

- *"Given the safety implications of fan flutter, Boeing and Roll-Royce do not consider it prudent to delay fleet wide incorporation of an automated KOZ by a further three to four years to correct a minor EPR oscillation which is unlikely to occur in service. Such a delay would not be in the Public Interest."*

Federal Register publication

A summary of the petition was published in the *Federal Register* on March 30, 2010 (75 FR 15771). No comments were received.

The FAA's analysis

Background

The FAA acknowledged the December 16, 2009, Boeing petition by means of an FAA letter dated December 29, 2009. In that letter the FAA stated in part that:

> *"It is not clear how the proposed design can be found to comply with § 25.779(b)(1), § 25.939 or § 25.1309(a). Boeing may want to consider revising their petition for exemption accordingly. Boeing is further advised that, if at all possible, their petition should be supplemented to provide more substantial assurance that there are no ground handling concerns due to this software anomaly. For example, how can we know for a fact that if we are approaching a gate through several inches of snow over a layer of ice (i.e., higher than normal required breakout power with lower than normal nose wheel steering effectiveness), this anomaly would not impede predictable lateral directional control and thus increase the risk of striking a gate, another airplane, ground equipment, or some other obstacle?"*

Boeing responded by means of a letter dated February 09, 2010. All of the above letters are available in Regulatory Docket FAA-2009-1218.

The FAA ascertained that the part numbers for the new "Issue 17" equipped FAFC's would be FAFC2000-11BK5 and FAFC2000-12BK6.

Introduction

To obtain this exemption, the petitioner must show, as required by § 11.81(d), that granting the request is in the public interest, and, as required by § 11.81(e), that the exemption will not adversely affect safety or that a level of safety will be provided that is equal to that provided by the rules from which the exemption is sought.

Effect on Safety

The results of all the assessments, both analyses and tests, provided by the petitioner indicate that the noncompliant LCO characteristic of Issue 17 software is nothing more than a barely perceptible nuisance, unlikely to occur much less pose any substantial threat to an airplane. This is a conclusion reportedly shared by the petitioner, the engine manufacturer and the operator personnel involved in these assessments.

In contrast, the KOZ characteristic of Issue 17 software is expected to reduce the exposure to fan flutter sufficiently to be considered an acceptable corrective action for what currently is a significant threat to continued operational safety. By granting this exemption we avoid an unacceptable delay in the implementation of that corrective action.

In consideration of the above, the FAA concludes that granting this petition will have the net effect of improving the level of safety within the affected fleet.

Public Interest

If the FAA were to deny this petition, the resulting increase in the exposure to fan flutter would eventually make the cumulative probability of experiencing a fan failure unacceptable. This could lead to grounding the affected airplanes.

If the FAA grants this petition, we avoid the increased exposure to fan flutter, but expose the affected fleet to what by all accounts is a rare undesirable, but operationally insignificant, LOC characteristic.

In consideration of the above, the FAA concludes that granting this petition is in the public interest.

The FAA's decision

In consideration of the foregoing, I find that a grant of exemption is in the public interest and will not adversely affect safety. Therefore, pursuant to the authority contained in 49 U.S.C. 40113 and 44701, delegated to me by the Administrator, The Boeing Company is hereby granted an exemption from 14 CFR 25.779(b)(1), 25.1301(d), and 25.1309(a), for all Model 747-400, 747-400F, and 767-300 airplanes produced prior to this granting and equipped with Rolls-Royce RB211-524G/H engines.

The petition is granted to the extent necessary to allow type certification of the service instructions to install FAFC Issue 17 software without a showing of compliance with the stipulated regulations as they relate to the "non-operationally significant minor EPR limit cycle oscillation during certain ground operation, at aircraft speeds below 35 knots IAS".

Issued in Renton, Washington, on MAY 25 2010

Ali Bahrami
Manager, Transport Airplane Directorate
Aircraft Certification Service